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ABSTRACT

The National Assessment of Educational Progress (NAEP) is an information-gathering project that surveys the educational attainments of 9-year-olds, 13-year-olds, 17-year-olds, and adults (ages 26-35) in various learning areas. All areas are assessed by a group of educators who design objectives for each area and create measurement tools appropriate to the objectives. When the exercises prepared by the test developers have passed extensive reviews by subject-matter specialists and measurement experts, they are administered to probability samples of various populations. Approximately 100,000 persons participate annually in these exercises. This report includes information on the ability of American youth to utilize the inquiry skills stressed in the new science curricula. The students participated in eight individualized activities which included the use of scientific apparatus to conduct testing procedures and simple experiments, the application of knowledge to the observation of materials in order to make generalizations, and the demonstration of principles by using models. Descriptions are given of the eight activities which were designed for students of ages 9, 13, and 17, and specifications are included for the sample populations which took part in the study. The results of the assessment are reported for each activity and include a breakdown according to geographical region, sex, color, parental education, and size and type of community. (MLH)

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NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

SELECTED RESULTS FROM THE NATIONAL ASSESSMENTS OF SCIENCE:

Scientific Principles and Procedures

Science Report No. 04-S-02

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

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FOREWORD

The National Assessment of Educational Progress (NAEP) is an information-gathering project that surveys the educational attainments of 9-year-olds, 13-year-olds, 17-year-olds and adults (ages 26—35) in 10 learning areas: art, career and occupational development, citizenship, literature, mathematics, music, reading, science, social studies and writing. At least one area is assessed every year, and all areas are periodically reassessed in order to measure educational progress. Each assessment is the product of several years work by a great many educators, scholars and lay persons from all over the country. Initially, these people design objectives for each area, proposing general goals that they feel Americans should be achieving in the course of their education. These goals are reviewed by more people and then passed along to developers of tests, whose task it is to create measurement tools appropriate to the objectives.

When the exercises prepared by the test developers have passed extensive reviews by subject-matter specialists and measurement experts, they are administered to probability samples of various populations. The people who compose those samples are chosen in such a way that the results of their assessment can be generalized to an entire national population. That is, on the basis of the performance of about 2,500 9-year-olds on a given exercise, we can generalize about the probable performance of all 9-year-olds in the nation. Approximately 100,000 persons participate annually.

After assessment data have been collected, scored and analyzed, National Assessment publishes reports to present the results as accurately as possible. Not all exercise results are released for publication. Because NAEP will administer some of the same exercises again in the future to determine whether the performance level of Americans has improved or declined, it is essential that they be kept secret in order to preserve the integrity of the study. If the unreleased exercises can be discussed without revealing their content, they are examined. However, the discussion is much less detailed than it is for the released exercises.

National Assessment also publishes a general information yearbook that describes all major aspects of the assessment process. This volume defines the categories by which results are reported and elaborates on the scientific procedures utilized. The reader who desires more detailed information about how NAEP defines its groups, prepares and scores its exercises, designs its sample and analyzes and reports its results should consult the *General Information Yearbook, Report 03/04-GIY*, which is available, as are all Assessment reports, through the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

ACKNOWLEDGMENTS

Assessing science achievement of young Americans throughout the nation is an undertaking of major proportions. Certainly it could not become a reality without substantial contributions by a great number of people, not the least of whom are the students, teachers and administrators who made the effort possible to begin with. Unfortunately, it is not possible to acknowledge all the important contributions to the Assessment.

Dozens of consultants — both subject-matter specialists and lay persons — developed and reviewed these materials under the general guidance of the National Assessment of Educational Progress (NAEP) staff. Administration of exercises was handled by the Research Triangle Institute (RTI) and the Measurement Research Center (MRC). Scoring and processing were carried out by MRC and by NAEP staff members.

The preparation of this report was a collaborative effort of the National Assessment staff. Special thanks must go to the Data Processing, Research and Analysis and Utilization/Applications Departments and to Robert Crane, who wrote this report.

J. Stanley Ahmann
Project Director

INTRODUCTION

The last 20 years have witnessed a major reorganization of science education. The most visible result of the changes in science education during this period has been the development of the "new science" curricula. Although these curricula embody a variety of approaches, they share a common purpose. In all cases, science is viewed primarily as a mode of inquiry. The new curricula all utilize an inquiry approach, with particular emphasis placed on using scientific apparatus, laboratory techniques and procedures as learning devices. These curricula emphasize the conceptualization of science knowledge — the ability to generalize and bring together otherwise discrete facts. Materials for all of these new curricula include planned classroom and laboratory activities.

While science materials and teacher training in science have changed dramatically, it is not clear how much of this change has "trickled down" to the science classrooms across the nation. Actual statistics on the adoption of new science materials or the effectiveness of science-education programs are difficult to gather and generally insufficient when available. It seems clear, however, from the data that are available, that overwhelming use of the new materials has not occurred.

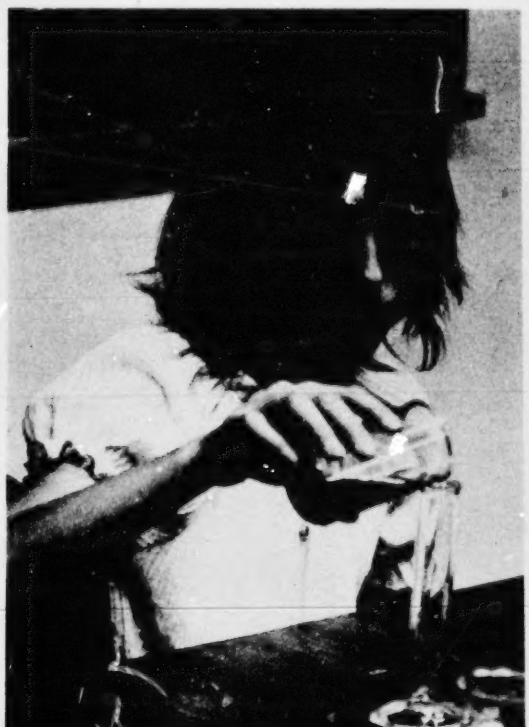
As one of the unique features of the national assessment of science, the National Assessment of Educational Progress (NAEP) gathered information on the abilities of American youth to utilize the inquiry skills stressed in the new science. As part of the 1972—73 NAEP science assessment, students participated in a number of individualized activities. The tasks included the use of scientific apparatus to conduct testing procedures and simple experiments, the application of knowledge to the observation of materials in order to make generalizations and the demonstration of principles by using models. It was a costly and time-consuming effort, but it provides us with information that cannot be found elsewhere. It represents the first outcome information on a national level bearing on the new science approach. Coupled with the available information on adoption and teacher education, the status of the new science approach in the schools becomes somewhat clearer.

CONDUCTING A SIMPLE TEST: COLORED-WATER ACTIVITY, AGE 9

Each 9-year-old received two premeasured containers of colored water. One was a tall container of red-colored water; the other, a short container of green-colored water. Each container had 40 milliliters of water in it, but the student was not told this. The following materials were placed in front of each student: a 12-inch ruler, two clear plastic glasses, a 100-milliliter graduated cylinder and some paper towels.

In order to get the students to form a hypothesis before attempting the activity, they were asked the following question:

"Do you think one of the containers has more water in it?"



The percentage of students giving each answer is shown below.

Yes	58%
No	40
I don't know	1
No response	0

Approximately two out of every three of the 58% of the 9-year-olds who responded "yes" thought the amount of water in the tall, red container was greater.

The students were next asked to show the administrator how they would find out if one of the containers had more water in it. They were told they could use any of the materials that had been given to them. Eighty-two percent of the 9-year-olds were able to demonstrate an acceptable testing procedure in this activity. The various types of procedures used are shown in Table 1.

TABLE 1. Procedures Used to Test a Hypothesis – Colored-Water Activity*

	Age 9
Poured green water into one plastic glass and red water into another and compared them	54%
Poured the colored water from each container into the graduated cylinder in turn and compared the measurements	22
Poured the red water into a plastic glass and compared it to the green water in the container	6
Unacceptable procedures	14
I don't know	2
No response	2

**Refer to Appendix B, Table B-2, for more detailed breakdowns of results for each activity.*

Although the students were not asked if the procedure they used led them to change their original hypothesis, the administrators were instructed to record any changes they observed. Thirty percent of the 9-year-olds who originally said one container had more water in it changed their hypothesis after collecting pertinent data. After conducting the test, they felt the containers had equal amounts of water in them. This activity appeared to be a good learning experience for the students as well as a test of their ability to demonstrate a simple testing procedure.

CONDUCTING A SIMPLE TEST: VOLUME-OF-ROCK ACTIVITY, AGES 13 AND 17

In another activity designed to find out whether 13- and 17-year-olds knew and could accomplish a simple testing procedure, the students were asked to determine the volume of a small rock. Each student was given a small nonporous rock, a 12-inch ruler, a graduated cylinder, spring scales, water in a jar, a piece of string and the following instructions:

In front of you are a small rock and several pieces of apparatus. You are to use whatever apparatus you find necessary to find the VOLUME of the small rock. List all procedures and record all measurements you make in the Workbook in part A. I will be making the same measurements in the same way that you do. When you have determined the volume of the rock, record your answer in part B.

The workbook page appears below.

EXHIBIT 1. Page of Student Workbook, Volume-of-Rock Activity

A. Procedures Used _____ Measurements _____

_____ _____

_____ _____

_____ _____

_____ _____

B. The volume of the rock is _____

Use the space below to do any work:

_____

The various apparatus used by the students are shown in Table 2.

TABLE 2. Percentage of Students Using Various Apparatus – Volume-of-Rock Activity*

	Age 13	Age 17
Graduated cylinder with water	25%	50%
Graduated cylinder without water	7	4
Ruler	32	9
Spring scales	61	42
String	13	9

**Refer to Appendix B, Table B-3.*

Seventeen-year-olds clearly had a better grasp of the procedures that might be employed to successfully find the volume of the rock, although almost as many (42%) 17-year-olds weighed the rock on the spring scales as measured the displacement of water in a graduated cylinder (50%). However, at age 13, 61% of the students used the spring scales, while only 25% measured the water displacement. The concept of volume was, at both ages, often confused with weight.

Beyond the problems of confusing volume with weight, some students had difficulties with the measurements and calculations as well. At the conclusion of this activity, 11% of the 13-year-olds and 36% of the 17-year-olds had correctly found the volume of the rock. (See Table B-4 in Appendix B.) That is to say, 14% of the 13- and 17-year-olds who had chosen the correct procedure could not carry it out to a successful conclusion.

CONDUCTING A SIMPLE EXPERIMENT: WATER-TEMPERATURE ACTIVITY, AGES 9, 13 AND 17

For this activity, the students were given two cups with equally measured amounts of water in them. One cup was clearly labeled HOT; the other, COLD. The administrator emphasized the fact that both the cups had an equal amount of water in them. The administrator, while explaining the procedure to the students, then heated the water in the cup labeled HOT until the water was hot to the touch. The student was given two centigrade thermometers and the workbook page shown in Exhibit 2.

EXHIBIT 2. Workbook Page for Water-Temperature Activity

A. Temperature of hot water is _____° C.

B. Temperature of cold water is _____° C.

C. I THINK temperature of the mixture will be _____° C.

D. Temperature of the mixture is _____° C.

Use the space below to do any work:

The students were asked if they knew how to use a thermometer. Their responses are indicated in Table 3.

TABLE 3. Do You Know How to Use a Thermometer? – Water-Temperature Activity*

	Age 9	Age 13	Age 17
Yes	72%	82%	86%
No	25	16	10
don't know	3	2	1
No response	0	0	3

**Refer to Appendix B, Table B-5.*

The students were then shown how to use a thermometer. Included in the explanation was a demonstration on how to hold it carefully, insert it in the water so as not to tip the cup, wait for the temperature to register and how to read it. Having seen this demonstration, the students were asked to put a thermometer in each cup and record the temperature on their workbook sheet under A and B.

After the students recorded their readings, the administrator told them that they were going to mix the hot and cold water in a third cup. The students were then asked:

TABLE 4. Percentage of Students Verbally Explaining the Results of Mixing the Water – Water-Temperature Activity*

	Age 9	Age 13	Age 17
Temperature in words such as "halfway between hot and cold" or an actual temperature, and an indication that it is an average	7%	21%	35%
Vague response such as "somewhere in between" or an actual number that is incorrect, with no indication that the average was sought	42	50	43
A sum of the two temperatures	19	7	2
The hot or cold temperature	0	1	0
Other unacceptable	24	17	15
I don't know	5	3	1
No response	2†	1†	3†

**Refer to Appendix B, Table B-6.*
†Figures may not add to 100% due to rounding error.

"Tell me in words what the temperature of the mixture will be compared to the temperatures of the hot and cold water."

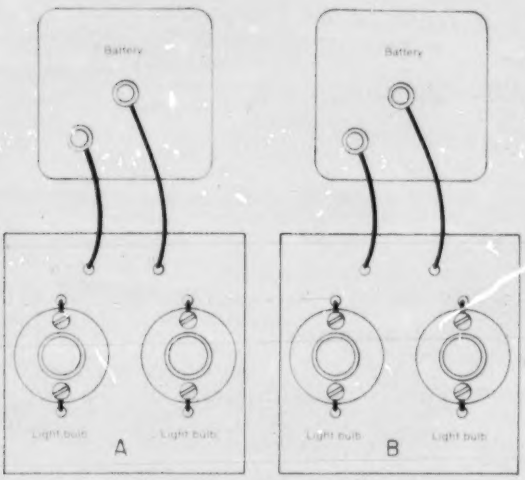
Approximately one-third of the 17-year-olds, and appreciably fewer 9- and 13-year-olds, could do so acceptably. Table 4 shows the percentage of students at each age giving various types of responses.

Although the percentage of students able to predict the result of a mixture never exceeded 35% (at age 17), it did rise when they were asked to use the figures they had put in their workbooks under A and B to predict the temperature of the mixture. Given the actual numbers, 12% of the 9-year-olds, 34% of the 13-year-olds and 52% of the 17-year-olds calculated a prediction within a two-degree tolerance.

DEMONSTRATING A SIMPLE EXPERIMENT: CIRCUIT-BOARD ACTIVITY, AGE 17

For this activity, 17-year-olds were asked to do an experiment to find out how two light bulbs were wired together. In order to do the experiment, they were given two circuit boards with batteries attached, four loose light bulbs and the workbook pages shown in Exhibit 3.

EXHIBIT 3. Workbook Pages, Circuit-Board Activity



I don't know

Instruction Sheet

In front of you are two electrical setups consisting of batteries, wires, light bulbs, sockets, and circuit boards. The batteries and the light bulbs are IDENTICAL. The wiring INSIDE the circuit board is different in each setup.

You are to do an experiment to find how the two bulbs are wired together. However, you are not to take the boards apart. After your experiment, draw the hidden wires on the drawings for setup A and setup B. You may do the experiment and draw the wires at the same time, if you wish.

To measure the students' ability to complete the experiment, they were asked to draw the

TABLE 5 Percentage of Students Giving Various Responses – Circuit-Board Activity*

	Box A Parallel Wiring	Box B Series Wiring
Wired correctly	23%	17%
Confused series and parallel wiring	4	12
Completely unacceptable wiring	54	52
I don't know	12	12
No response	7	7

**Refer to Appendix B, Table B-7.*

wiring diagram of the circuit boards in their workbooks. Circuit board A was wired parallel, and circuit board B was in series. However, the wiring was hidden and they were not told this. The results of the activity are shown in Table 5.

As Table 5 indicates, fewer than 3 out of 10 (27% to 29%) 17-year-olds have a rudimentary understanding of parallel and series wiring. Of these, even fewer correctly understand the differences. Twenty-three percent of the 17-year-olds correctly wired the parallel circuit boa.d, and 17% of this age level correctly wired the series circuit board. As many as 12% of the 17-year-olds confused series and parallel wiring and, therefore, cannot be said to understand it.

APPLYING KNOWLEDGE TO DIRECT OBSERVATIONS: ROCK-TYPE ACTIVITY, AGES 9, 13 AND 17

To find out whether students could apply knowledge of basic scientific concepts to direct observations of materials, 9-year-olds, 13-year-olds and 17-year-olds were presented with an activity involving the observation of three distinct rock types. Each student was given three distinctly different rocks to observe: number one was yellow-and-purple-banded sandstone, number two was translucent quartz and number three was coarse-grained granite. The rocks were not identified by name but simply labeled one, two and three.

The students were asked:

"Which one of these rocks was MOST likely formed under water?"

At least three out of every five students at each age level correctly chose the sedimentary rock, sandstone. Table 6 provides the exact percentages at each age level.

TABLE 6. Percentage of Students at Each Age Selecting Various Rock Types*

	Age 9	Age 13	Age 17
Sandstone	60%	71%	78%
Quartz	19	14	11
Granite	20	14	10
I don't know	1	1	1

**Refer to Appendix B, Table B-8.*

As a follow-up question, the students were asked why they chose the rock they did. The percentages of respondents able to express an acceptable reason were low at all three age levels. Only 24% of the 17-year-olds, 16% of the 13-year-olds and 7% of the 9-year-olds could do so. Table 7 gives the percentage of students at each age level giving any reasons, either acceptable or unacceptable, for their choice. Among respondents answering acceptably, those who used the word "sedimentary" or some variation of it were considered to have exhibited a higher level of response than the others. Therefore, the percentage of students so doing is shown in a separate category labeled "high-level acceptable reason."

TABLE 7. Percentage of Students Giving Various Reasons for Their Choice of Rock Type*

	Age 9	Age 13	Age 17
High-level acceptable reason	1%	4%	8%
Other acceptable reason	6	11	18
Unacceptable reason	88	80	70
Ended the exercise with first question	1	1	1
I don't know	4	3	3
No response	1†	0†	1†

**Refer to Appendix B, Table B-9.*
†Figures may not add to 100% due to rounding error.

There was a large difference between the percentages of students able to choose the correct rock and the percentages able to explain their choice. Table 8 compares these figures. Perhaps intuitively choosing the correct rock is enough, but, judging from the unacceptable responses, that is a doubtful conclusion. Choices based on reasons such as "It looks like it" or "I found one like it before" do not reflect the influence of a scientific approach.

TABLE 8. Comparison Between Choice of Sandstone and Acceptable Explanation – Rock-Type Activity

	Percent Selecting Sandstone	Percent Giving an Acceptable Explanation
Age 9	60%	7%
Age 13	71	15
Age 17	78	26

APPLYING KNOWLEDGE TO DIRECT OBSERVATIONS: PHOTOCELL-BOX ACTIVITY, AGES 9, 13 AND 17

In another activity designed to learn whether students could apply knowledge to direct observations in order to make some generalizations, 9-year-olds, 13-year-olds and 17-year-olds were given a small, black box and a flashlight. The box contained a small motor with a spinner attached to it, which was activated by a photocell. Students were asked to shine the flashlight into the box at the light-sensitive hole, which was pointed out, and tell the administrator what they observed. The students were not given any information about the box, however.

Nine out of 10 students at all three age levels were able to acceptably describe what occurred. Table 9 shows the percentages of students at each age that gave various observations of the activity.

TABLE 9. Percentage of Respondents Giving Various Observations – Photocell-Box Activity*

	Age 9	Age 13	Age 17
Acceptable observation	90%	93%	92%
Unacceptable response	8	7	6
I don't know	1	0	0
No response	1	0	2

**Refer to Appendix B, Table B-10.*

Students were next asked to explain what they thought happened inside the box when the light was shined into the box. As might be expected, the percentage of acceptable explanations dropped sharply. Table 10 shows the percentage of respondents giving various explanations for the observed activation of a motor by the flashlight.

As Table 10 indicates, only 4% of the 17-year-olds were able to give well-developed explanations of the photocell activity. The highest percentage of acceptable responses at all age levels was on a lower level and was either incomplete or quite vague. A large majority of the students gave either incorrect reasons or said they did not know the reason.

Finally, students were asked what they thought was in the box. They were told they could examine it closely but that they could not try to take it apart. On this more concrete level where relationships were not demanded, the percentage of acceptable responses increased appreciably. Table 11 indicates the various contents suggested by the students.

TABLE 10. Percentage of Respondents Giving Various Explanations of Their Observation – Photocell-Box Activity*

	Age 9	Age 13	Age 17
Mentions photocell and motor, indicates the relationship	0%	2%	6%
Mentions photocell, partially describes the mechanism	1	2	5
Indicates vague awareness of a mechanism that has been activated	4	13	14
Unacceptable explanations (gives only observations, very vague or incorrect reasons)	69	62	57
I don't know	22	20	15
No response	4	1	2†

**Refer to Appendix B, Table B-11.*
†Figures may not add to 100% due to rounding error.

TABLE 11. Percentage of Respondents Suggesting Various Contents of the Box – Photocell-Box Activity*

	Age 9	Age 13	Age 17
Specifies battery, photocell and/or motor and other items actually in the box	42%	49%	58%
Describes plausible mechanism not actually in the box	2	7	5
Describes far-fetched mechanism or does not specify one at all	37	29	21
I don't know	15	15	15
No response	3†	1†	2†

**Refer to Appendix B, Table B-12.*
†Figures may not add to 100% due to rounding error.

DEMONSTRATING PRINCIPLES USING A MODEL: ROTATION-AND-REVOLUTION ACTIVITY, AGES 9, 13 AND 17

In this activity, students were asked to explain the daily and yearly earth cycles by means of a demonstration. Before beginning the activity, three spheres were placed on a flat surface in front of the student. The earth, represented by a white ping-pong ball with the North and South poles and equator drawn on it, was placed directly in front of the student. The sun, represented by an orange ball approximately three inches in diameter, was placed about a foot from the earth on the respondent's left. The moon, represented by a small, yellow marble, was placed about six inches from the earth on the student's right. Each was pointed out in turn. Exhibit 4 shows the scoring instruction sheet used by the administrators for this activity.

EXHIBIT 4. Diagram and Instructions Given to Activity Administrator

Parts A and B: Cause of Day and Night

One counterclockwise ROTATION (seen from above) looks like the illustration below. The Earth sphere is spun in place on its axis exactly once around (or within the limits 3/4 to 1 1/4 times around). Direction of rotation is not critical for Part A; however, correct counterclockwise direction is shown so you will recognize it if respondent demonstrates it for Part B. Ignore any movement of the other two spheres, and/or any other movements of the Earth sphere.

Parts C and D: Cause of a Year

One counterclockwise REVOLUTION (seen from above) looks like the illustration below. The Earth sphere is moved out and around behind the Sun sphere and returned to its original place (or within 2" either way) in one complete orbit which may be either elliptical or more nearly round. Direction of revolution is not critical for Part C; however, correct counterclockwise revolution is shown so you will recognize it if respondent demonstrates it for Part D. Ignore any movement of the Moon or Sun spheres, and/or any other movements of the Earth sphere.

Students were given the following instructions before being asked to demonstrate the cause of day and night:

Use any balls you may need to show me what causes a day and a night. You may move the balls around while you work out your answer. Then tell me when you are ready to demonstrate what happens in a 24-hour period to make one day and one night.

Rotation of the earth one full turn was considered a correct demonstration. About half (52%) of the 17-year-olds were able to correctly demonstrate the daily earth cycle. At age 13, 48% were able to do so. Thirty-five percent of the 9-year-olds demonstrated the daily cycle correctly as well. Table 12 shows the various responses given at each age.

TABLE 12. Percentage of Students Giving Various Responses – Demonstration of Daily Earth Cycle*

	Age 9	Age 13	Age 17
Correct demonstration	34%	48%	53%
Incorrect demonstration	54	46	39
I don't know	7	4	6
No response	4	1	2

**Refer to Appendix B, Table B-13.*

Students correctly demonstrating the cycle were asked which direction the earth would be spinning. As might be expected, appreciably fewer students could either say or demonstrate the counterclockwise, or eastward, rotation of the earth. Sixteen percent of the 9-year-olds, 24% of the 13-year-olds and 28% of the 17-year-olds could do so. In other words, approximately half of those who could demonstrate the rotation could demonstrate the counterclockwise direction of the rotation of the earth on its axis.

In another part of this activity, students were asked to demonstrate the cause of a year, using the same model. The following instructions were given:

Now, use any balls you may need to show me what causes a year. Once again you may move the balls around while you work out your answer. Then, tell me when you are ready to demonstrate what happens in a 365-day period to make a year.

One full revolution of the earth around the sun was considered a correct demonstration. Slightly larger percentages of 13- and 17-year-olds correctly demonstrated earth revolution than correctly demonstrated earth rotation. The percentage of 9-year-olds correctly demonstrating revolution was 2% lower than for rotation, however. Table 13 shows the various responses to the earth-revolution demonstration at each age level.

A comparison of Tables 12 and 13 shows that fewer students actually attempted the yearly cycle demonstration than attempted the daily cycle demonstration. Perhaps this indicates some fatigue or boredom with the activity on their part.

Students correctly demonstrating the revolution of the earth around the sun were asked the direction the earth would be revolving. As was the case with rotation, these percentages were lower. Only 20% of 9-year-olds, 28% of the 13-year-olds and 32% of the 17-year-olds could demonstrate that the revolution of the earth around the sun is counterclockwise.

TABLE 13. Percentage of Students Giving Various Responses – Demonstration of Yearly Earth Cycle*

	Age 9	Age 13	Age 17
Correct demonstration	33%	52%	60%
Incorrect demonstration	36	27	22
I don't know	25	19	16
No response	6	2	2

**Refer to Appendix B, Table B-14.*

DEMONSTRATING PRINCIPLES USING A MODEL: FAULTING-AND-FOLDING ACTIVITY, AGES 9, 13 AND 17

In this activity, students were asked to demonstrate two basic geological concepts — faulting and folding of the earth's crust. Each student was given two foam-rubber blocks placed side by side and the instructions shown in Exhibit 5.

EXHIBIT 5. Placement of Foam Blocks

The foam sheets represent a layer of rock in the Earth's crust. Use one or both of the foam blocks to demonstrate faulting of the Earth's crust; that is, show me a fault.

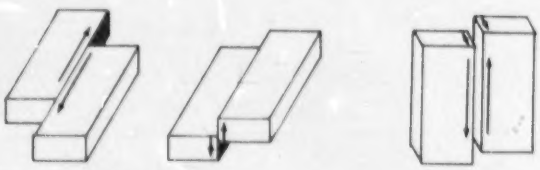
Use one or both of these foam blocks to demonstrate a fold in the Earth's crust.

The administrator was given an illustration of the correct demonstration procedures so that the students could be judged with consistency (see Exhibit 6).

EXHIBIT 6. Instruction Sheet Given to the Administrator

Part A: Faulting

Correct demonstration of a fault in the Earth's crust is illustrated below. Any of the relative positions of the two foam pieces shown will be acceptable; that is, respondent may offset them horizontally, vertically, or obliquely, as long as he moves the edge of one piece along the edge of the other. Any number of directions and amounts of displacement are possible, and any flat surface of the foam pieces may be used as the edge of the fault.



Part B. Folding

Correct demonstration of a fold in the Earth's crust is illustrated below. Any curved position of the foam piece will be acceptable; that is, respondent may arch the top surface upward or downward or wrinkle it into several small folds, as long as he shortens its length by curving its top surface. It is perfectly all right for him to hold the two pieces together in layers as he does this.

CORRECT DEMONSTRATIONS

NOTE: A complete fold of the foam piece such that its inner surfaces touch tightly together is *not* correct. While it is technically possible, it most likely indicates that the respondent is guessing on the basis of the common definition of the term "to fold." This type of incorrect response is illustrated below.

INCORRECT DEMONSTRATION

As shown in Table 14, about one out of three 17-year-olds could demonstrate either of these basic concepts of geology. At age 13, approximately one student in five could demonstrate either faulting or folding. Even fewer could do so at age 9.

The percentage of 9-year-olds correctly demonstrating folding was four times greater

than the percentage of that age level demonstrating faulting. This may in large part be due to the vocabulary of the activity. Over one-half (58%) of the 9-year-olds either did not attempt to demonstrate faulting or said "I don't know." The percentages of 9-year-olds giving similar responses to the demonstration of folding, however, was only 36%.

Very few students at any age level were able to correctly demonstrate both concepts. Only 2% of the 9-year-olds, 8% of the 13-year-olds and 16% of the 17-year-olds could do so.

TABLE 14. Correct Demonstration of Faulting or Folding of Earth's Crust*

	Percent Demonstrating Faulting	Percent Demonstrating Folding
Age 9	4%	16%
Age 13	20	22
Age 17	34	32

**Refer to Appendix B, Tables B-15 and B-16.*

SUMMARY

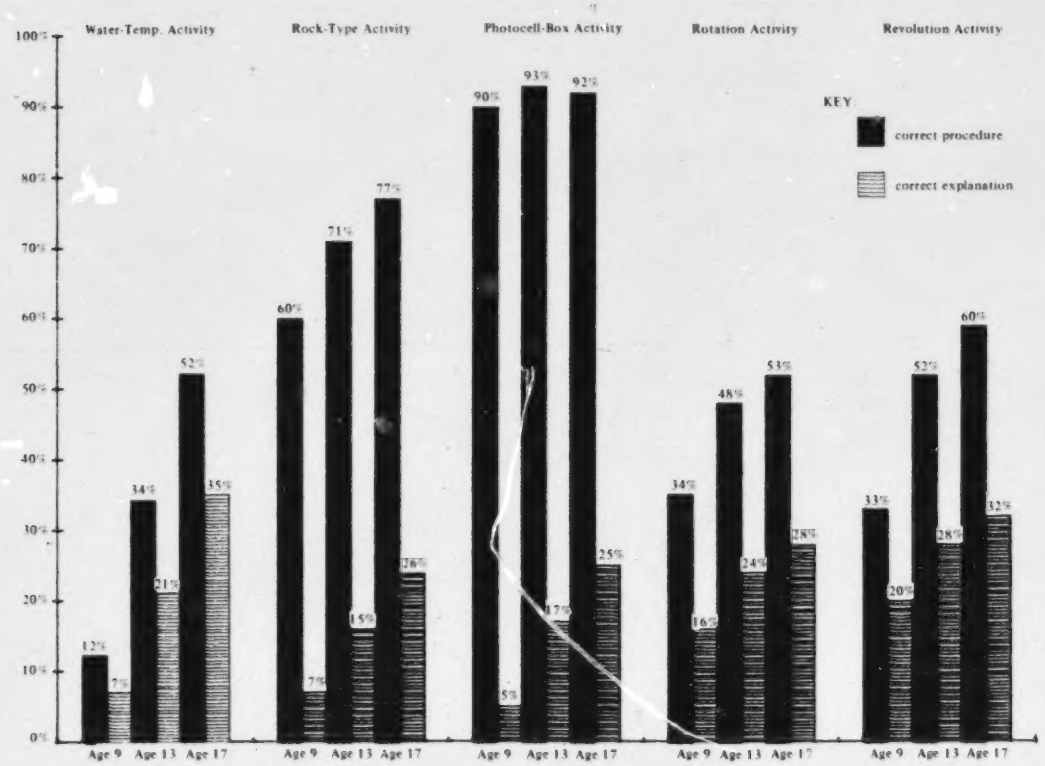
A number of activities were used at all three ages. A comparison of the results for these activities reveals the following general observations:

1. The percentage of students successfully able to perform these activities is directly related to their age. That is to say, 13-year-olds outperform 9-year-olds and 17-year-olds outperform 13-year-olds. The biggest change in abilities occurs between the ages of 9 and 13. Often 13-year-olds perform about as well as the 17-year olds.

2. There is a wide gap between the ability of students to demonstrate procedures and their ability to successfully explain these procedures. At all three age levels, the percentage of students able to do things was much greater than the percentage of students able to explain how, why or what they were doing.

Exhibit 7 graphically illustrates these two observations.

EXHIBIT 7. Summary Results for Selected Activities



APPENDIXES

The information in Appendixes A and B is supplementary. In Appendix A, the groups for which the National Assessment of Educational Progress provides information are precisely defined. Appendix B provides a copy of the actual activity and group results for each item discussed in the text. Besides documenting the performances of the various groups on these activities, these results provide precise information for those with specific data needs. For example:

1. Curriculum developers and/or publishers may want to compare National Assessment regional data to information they have about the use of their materials at the regional or community level.

2. School systems may want to compare performance levels of their students to national, regional or community results in order to see how they "measure up."

3. Classroom teachers may want to compare their students' performance to various other groups.

APPENDIX A

NATIONAL ASSESSMENT GROUPS

Regions

Results are reported by the four geographic regions defined by the Office of Business Economics, Department of Commerce. The states in each region are shown in Exhibit A-1.

EXHIBIT A-1. Definitions of National Assessment Regional Subpopulations*

Northeast	Southeast
Delaware	Arkansas
Connecticut	Florida
Maine	Virginia
New Hampshire	West Virginia
Rhode Island	Alabama
Vermont	Georgia
District of Columbia	Kentucky
Maryland	Louisiana
Massachusetts	Mississippi
New Jersey	North Carolina
Pennsylvania	South Carolina
New York	Tennessee
Central	**West**
Iowa	Alaska
Kansas	Hawaii
Nebraska	Idaho
North Dakota	Montana
South Dakota	Nevada
Minnesota	Wyoming
Missouri	Arizona
Illinois	Oregon
Indiana	Utah
Michigan	Colorado
Wisconsin	New Mexico
Ohio	Oklahoma
	California
	Texas
	Washington

**These regional subpopulation definitions are the same as those used by the Office of Business Economics, Department of Commerce.*

Sex

Results are reported separately for males and females at all age levels.

Color

Results are reported for whites and blacks. While respondents were classified into several other ethnic groups, including Puerto Ricans, Mexican-American and other or unclassified, the actual sample sizes realized were insufficient for reporting purposes.

Parental Education

Parental education refers to the highest level of education level reported by the respondent for either parent.

No high school

Neither parent has any formal education beyond the eighth grade.

Some high school

At least one parent has some formal education beyond the eighth grade, but neither parent has graduated from high school.

Graduated from high school

At least one parent has graduated from high school, but neither parent has any formal education beyond high school.

Post high school

At least one parent has some formal education beyond high school including any business-, professional- or trade-school training as well as college or university training.

Size and Type of Community (STOC)

The seven size-and-type-of-community (STOC) reporting categories are comprised of three "extreme" types of community (TOC) and four "residual" sizes of community (SOC). Each TOC category includes approximately 10% of the respondents at each age level; the remaining respondents are classified according to one of the SOC classifications.

Briefly, the three TOC categories are: (1) city areas where a high proportion of the adult population is either not regularly employed or on welfare and a low proportion is employed in professional or managerial positions; (2) rural areas where a high proportion of adults are farm workers and a low proportion are professional, managerial or factory workers; and (3) near-city and city areas where a high proportion of adults are employed in professional or managerial positions and a low proportion are factory or farm workers, not regularly employed or on welfare. Respondents are placed in one of these categories if the occupational profile and location of the school satisfy the extreme TOC definitions.

The remaining respondents at each age level are classified according to the size of community in which the school is located. The occupational profile is based on the employment categories summarized in Exhibit A-2.

For the in-school sample at each age, the school principal of each selected school provided estimates of the percentage of students whose parents fit into each occupational category.

The definitions used to classify respondents by STOC are presented in Exhibit A-3. The occupational index is computed using the occupational categories summarized in Exhibit A-2.

EXHIBIT A-2. Occupational Categories

Categories	Code
Professional or managerial personnel	A
Sales, clerical, technical or skilled workers	B
Factory or other blue collar workers	C
Farm workers	D
Not regularly employed	E
On welfare	F

EXHIBIT A-3. National Assessment Size-and-Type-of-Community (STOC) Reporting Categories

Reporting Category	Occupational Index*	Description
Low metro	E+F-A	Sample schools or segments in a city or metropolitan area of a city with a population greater than 200,000 and in the 90th–99th percentile of the low-metro index
Extreme rural	D-(C+2A)	Sample schools or areas with a population less than 10,000 and in the 90th–99th percentile of the extreme-rural index.
Small place		Sample schools or segments in a community with a population less than 25,000 and not classified as extreme rural
Medium city		Sample schools or segments in a city with a population between 25,000 and 200,000 and not classified as low metro or high metro
Main big city		Sample schools or segments within the city limits of a city with a population greater than 200,000 and not classified as high metro or low metro
Urban fringe		Sample schools or segments in the metropolitan area of a big city but outside the city limits and not classified as low metro, extreme rural or high metro
High metro	A-(C+D+E+F)	Sample schools or segments in a city or metropolitan area of a city with a population greater than 200,000 and in the 90th–99th percentile on the high-metro index

**See Exhibit A-2.*

APPENDIX B

GROUP RESULTS FOR EACH ACTIVITY

This appendix is keyed to the text so that readers can quickly and easily find additional information. Each activity is reproduced in its original form, and the data are keyed to the tables. For example, Table 1 on page 1 is keyed B-2. The following additional information is contained in appendix Tables B-2 through B-16. (See the following sample table — Table B-1.)

This type of information is available for each of the activities discussed in the text at all appropriate ages.

TABLE B-1. Sample Table

Age 9

	N-Count	Percent
National	2,177	82.2
Region		
Southeast	562	-4.2
West	551	-3.6
Central	538	5.6
Northeast	526	2.0
Sex		
Male	1,052	0.2
Female	1,125	-0.2
Color		
Black	393	-11.2
White	1,614	3.0
Parental education		
No high school	107	-18.5
Some high school	113	-7.1
Graduated high school	501	-0.2
Post high school	813	5.4
Size and type of community (STOC)		
Low metro	226	-9.2
Extreme rural	212	-15.2
Small places	706	1.8
Medium city	303	1.2
Main big city	247	-3.0
Urban fringe	251	5.6
High metro	232	7.3

The number of students nationally and for each group that responded to this activity.

The exact percentage of acceptable responses nationally.

The difference between the percentage of the nation that responded correctly and the percentage of the group that responded correctly.

COLORED-WATER ACTIVITY

Take out 12" ruler, tall container of red-colored water, short container of green-colored water, 2 plastic glasses, graduated cylinder and paper towels.

Give respondent container of red-colored water and container of green-colored water. Place other materials in front of respondent.

(Point to the container of red water.) This is water that has been colored red.

(Point to the container of green water.) This is water that has been colored green.

A. Do you think one of the containers has more water in it?

- ⬭ Yes (Go to B)
- ⬭ No (Go to C)
- ⬭ I don't know. (Go to C)
- ⬭ No response (Go to C)

B. Which container has more water in it?

- ⬭ Red
- ⬭ Green
- ⬭ I don't know.
- ⬭ No response

C. Show me how you would find out if one of the containers has more water in it. You may use any of the other things I have given you to find out.

List the steps that respondent uses to test his guess. The listing can be brief, with sketches, if helpful, but ALL STEPS should be listed. Note especially whether respondent "eyeballs" water levels. If respondent's own words are used, indicate them with quotation marks.

_____

_____

_____

Probe 1: If respondent stops ask, "IS THERE ANYTHING ELSE YOU CAN DO TO FIND OUT WHICH CONTAINER HAS MORE WATER IN IT?"

D. *DO NOT PROBE for changes in respondent's original guess, but record any changes he makes in his first guess below.*

- ○ *No change*
- ○ *Changed to "red has more"*
- ○ *Changed to "green" has more*
- ○ *Changed to "the same amount"*

TABLE B-2. Differences Between Group and National Performance – Colored-Water Activity

	Age 9	
	N-Count	**Percent**
National	2,177	82.2
Region		
Southeast	562	-4.2
West	551	-3.6
Central	538	5.6
Northeast	526	2.0
Sex		
Male	1,052	0.2
Female	1,125	-0.2
Color		
Black	393	-11.2
White	1,614	3.0
Parental education		
No high school	107	-18.5
Some high school	113	-7.1
Graduated high school	501	-0.2
Post high school	813	5.4
Size and type of community (STOC)		
Low metro	226	-9.2
Extreme rural	212	-15.2
Small places	706	1.8
Medium city	303	1.2
Main big city	247	-3.0
Urban fringe	251	5.6
High metro	232	7.3

VOLUME-OF-ROCK ACTIVITY

Place 12" ruler, graduated cylinder, non-porous rock, spring scales, water in jar, and string in front of respondent. Give respondent the Workbook opened to page 9.

In front of you are a small rock and several pieces of apparatus. You are to use whatever apparatus you find necessary to find the VOLUME of the small rock. List all procedures and record all measurements you make in the Workbook in part A. I will be making the same measurements in the same way that you do. When you have determined the volume of the rock, record your answer in part B.

Probe 1: If respondent does not proceed, say, "THINK OF SOME MEASUREMENTS YOU COULD MAKE WHICH WOULD GIVE YOU THE VOLUME OF THE ROCK."

A. *Indicate the equipment respondent uses.*

Yes	*No*	
○	○	*Graduated cylinder and water*
○	○	*Graduated cylinder and no water*
○	○	*Ruler*
○	○	*Spring scales*
○	○	*String*

B. *Indicate each measurement respondent makes. Check each measurement before respondent continues and record YOUR readings below.*

Yes	*No*	
○	○	*Initial water volume* _____ *ml*
○	○	*Final water volume* _____ *ml*
○	○	*Other (Specify):*

_____

_____

_____

C. *Did respondent calculate final volume minus initial volume?*

○ *Yes*

○ *No*

Remember to indicate in Part A ALL equipment used by respondent.

D. *Additional observations*

_____

_____

_____

_____

TABLE B-3. Differences Between Group and National Performance – Volume of Rock Activity, Part A

	Age 13		Age 17	
	N-Count	Percent	N-Count	Percent
National	2,175	24.8	2,165	50.4
Region				
Southeast	536	-5.7	545	-13.1
West	547	-4.3	537	2.5
Central	556	-0.4	539	3.9
Northeast	536	10.1	544	3.7
Sex				
Male	1,082	4.1	1,055	8.2
Female	1,093	-4.2	1,110	-7.8
Color				
Black	377	-4.3	344	-28.0
White	1,622	1.7	1,690	4.0
Parental education				
No high school	187	-7.7	154	-5.4
Some high school	209	-6.7	240	-19.5
Graduated high school	746	0.0	687	-3.8
Post high school	812	5.4	966	10.3
Size and type of community (STOC)				
Low metro	218	-7.8	252	-16.7
Extreme rural	226	-10.3	205	-13.3
Small places	704	-1.9	760	1.6
Medium city	297	4.7	298	4.4
Main big city	230	-1.4	187	-13.1
Urban fringe	279	5.5	249	4.2
High metro	221	8.0	214	15.9

TABLE B-4. Differences Between Group and National Performance – Volume of Rock Activity, Part B

	Age 13		Age 17	
	N-Count	Percent	N-Count	Percent
National	2,175	11.4	2,165	36.0
Region				
Southeast	536	-5.8	545	-12.3
West	547	-2.8	537	2.5
Central	556	0.4	539	4.4
Northeast	536	7.7	544	2.6
Sex				
Male	1,082	2.5	1,055	8.3
Female	1,093	-2.5	1,110	-7.9
Color				
Black	377	-7.3	344	-24.1
White	1,622	1.8	1,690	4.0
Parental education				
No high school	187	-8.5	154	-10.7
Some high school	209	-6.0	240	-16.9
Graduated high school	746	-0.1	687	-3.2
Post high school	812	4.8	966	9.4
Size and type of community (STOC)				
Low metro	218	-6.3	252	-15.1
Extreme rural	226	-5.7	205	-11.4
Small places	704	-1.3	760	-0.8
Medium city	297	1.8	298	5.7
Main big city	230	-2.1	187	-7.9
Urban fringe	279	3.0	249	3.8
High metro	221	8.6	214	15.9

WATER-TEMPERATURE ACTIVITY

Take out 3 styrofoam cups, 2 plastic measuring cups, 2 Centigrade thermometers, a plastic bottle containing cold water (the water in the bottle should be as cold as is readily available), a water heater, and a few paper towels. Place all of the materials in front of you.

(Measure out 50 milliliters of the cold water into each of the 2 measuring cups.) I am measuring out 50 milliliters of cold water into each of these two measuring cups. You see the water is equal. *(Indicate to respondent that the measuring cups contain the same amount.)*

(Pour the water from the measuring cups into 2 of the styrofoam cups.) Now, I will pour the water into each of your cups, and heat the water in the one labeled HOT until it is quite hot. *(Place the water heater into the cup labeled HOT and heat a few seconds until water is hot to the touch.)*

(Place the 2 cups before respondent.) The two cups are for you to work with. Remember, the one labeled HOT contains a certain amount of hot water and the one labeled COLD contains the SAME AMOUNT of cold water.

Give respondent the 2 thermometers and the Workbook opened to page 11.

A. I have also given you two thermometers. Do you know how to use a thermometer?

- ⬭ Yes (Go to C)
- ⬭ No (Go to B)
- ⬭ I don't know. (Go to B)
- ⬭ No response (Go to B)

B. *Show respondent how to use a thermometer. Include: how to hold carefully, insert in water so as not to tip the cup, wait a period of time, and read.*

C. Put a thermometer into each cup of water and record the temperatures in Part A and Part B.

After respondent reads and records the temperatures of the hot and cold water, read and record your readings below. If the discrepancy between your readings and respondent's readings exceeds 2 degrees, help respondent to read the thermometers and have him record correct readings.

_____° *C Hot water*

_____°*C Cold water*

D. *Did you help respondent read the thermometers?*

⬭ *Yes*

⬭ *No*

E. *(Place the third styrofoam cup in front of respondent.)* We are going to mix the hot and cold water together in this cup. Tell me in words what the temperature of the mixture will be compared to the temperatures of the hot and cold water.

_____

_____

_____

Probe 1: If respondent gives a numerical response, record and ask, "WHY DO YOU THINK THE TEMPERATURE WOULD BE (insert respondent's numerical response) DEGREES?"

Go to G.

For any other response OR if no response, go to F.

F. Use the temperatures you recorded for the hot and cold water to predict the temperature of the mixture. If you want to do any figuring, you may use the space in the Workbook. Put your prediction in Part C.

⬭ *Did not attempt this part of exercise*

G. Now pour the hot and cold water into the third cup and record the temperature in Part D.

⬭ *Did not attempt this part of exercise*

TABLE B-5. Differences Between Group and National Performance — Water-Temperature Activity, Part A

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,176	71.6	2,063	82.2	2,176	85.7
Region						
Southeast	535	-2.2	508	-7.2	564	-5.5
West	546	-8.0	505	-3.6	529	-4.7
Central	555	6.3	527	2.5	540	4.9
Northeast	540	2.8	523	7.2	543	3.4
Sex						
Male	1,090	7.3	1,002	4.0	1,068	3.8
Female	1,086	-7.6	1,061	-3.9	1,108	-3.9
Color						
Black	383	-9.8	360	-18.7	375	-12.7
White	1,639	3.2	1,553	4.1	1,675	3.2
Parental education						
No high school	117	-8.7	154	-13.3	164	-21.2
Some high school	117	-2.4	229	-11.9	267	-10.9
Graduated high school	582	0.7	697	1.0	689	1.1
Post high school	790	7.8	776	7.3	925	5.3
Size and type of community (STOC)						
Low metro	224	-9.3	214	-10.1	229	-5.7
Extreme rural	220	-2.6	196	-1.6	210	0.3
Small places	710	-0.5	684	-1.3	762	-0.5
Medium city	327	2.1	278	-0.6	306	1.1
Main big city	228	1.6	224	-1.8	188	-1.5
Urban fringe	255	1.4	255	3.7	250	-1.1
High metro	212	3.7	212	8.8	231	5.9

TABLE B-6. Differences Between Group and National Performance – Water-Temperature Activity, Part E

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,176	7.3	2,063	21.4	2,176	35.4
Region						
Southeast	535	-3.0	508	-3.2	564	-6.0
West	546	-0.3	505	-5.1	529	-0.1
Central	555	3.3	527	3.0	540	6.3
Northeast	540	-0.6	523	4.4	543	-1.8
Sex						
Male	1,090	-0.8	1,002	1.6	1,068	5.7
Female	1,086	0.8	1,061	-1.5	1,108	-5.8
Color						
Black	383	-4.5	360	-13.6	375	-18.2
White	1,639	1.3	1,553	2.9	1,675	3.7
Parental education						
No high school	117	-2.4	154	-7.2	164	-12.0
Some high school	117	-3.6	229	-6.8	267	-12.0
Graduated high school	582	-0.4	697	-0.9	689	-2.7
Post high school	790	2.9	776	6.5	925	9.2
Size and type of community (STOC)						
Low metro	224	-3.7	214	-8.8	229	-15.6
Extreme rural	220	0.4	196	7.6	210	-0.7
Small places	710	-0.6	684	0.2	762	-1.6
Medium city	327	3.0	278	-0.9	306	8.4
Main big city	228	-3.4	224	-4.5	188	-8.6
Urban fringe	255	0.8	255	2.4	250	-2.0
High metro	212	2.2	212	0.7	231	14.0

CIRCUIT-BOARD ACTIVITY

Place 2 circuit boards with batteries attached and 4 loose light bulbs in front of respondent and give respondent the Workbook opened to pages 12 and 13, turned sideways. Read all instructions with him before asking him to carry them out.

In front of you are two electrical setups consisting of batteries, wires, light bulbs, sockets, and circuit boards. The batteries and the light bulbs are IDENTICAL. The wiring INSIDE the circuit board is different in each setup.

You are to do an experiment to find how the two bulbs are wired together. However, you are not to take the boards apart. After your experiment, draw the hidden wires on the drawings for setup A and setup B. *(Point to the Workbook.)* You may do the experiment and draw the wires at the same time if you wish.

Probe 1: If respondent does not attempt to carry out experiment, ask, "WHERE DO YOU THINK YOU MIGHT START?"

If Workbook page is left blank, fill in 1 oval below.

- ⬭ *Attempted exercise, erased entries*
- ⬭ *Attempted exercise, made no entries*
- ⬭ *Did not attempt exercise*
- ⬭ *I don't know.*

TABLE B-7. Differences Between Group and National Performance – Circuit-Board Activity

	Age 17		
	N-Count	Percent Parallel	Percent Series
National	2,159	22.8	17.0
Region			
Southeast	549	-6.3	-2.0
West	542	2.4	2.8
Central	529	4.7	2.9
Northeast	539	-2.4	-4.2
Sex			
Male	1,041	18.7	12.0
Female	1,118	-17.7	-11.3
Color			
Black	344	-13.4	-12.3
White	1,692	2.5	2.1
Parental education			
No high school	165	-9.3	-10.5
Some high school	264	-7.6	-6.4
Graduated high school	676	-2.0	-1.6
Post high school	937	5.4	4.8
Size and type of community (STOC)			
Low metro	226	-7.7	-7.0
Extreme rural	205	2.5	-5.7
Small places	774	0.8	0.2
Medium city	301	3.0	-0.2
Main big city	189	-5.0	-1.6
Urban fringe	252	-1.6	0.3
High metro	212	3.2	9.3

ROCK-TYPE ACTIVITY

Place 3 rock specimens in front of respondent in 1, 2, 3 order. Do NOT identify the rocks by name.

A. Which one of these rocks was MOST likely formed under water?

- ⬭ Rock 1 (Go to B)
- ⬭ Rock 2 (Go to B)
- ⬭ Rock 3 (Go to B)
- ⬭ I don't know. (End the exercise)

Probe 1: If respondent hesitates say, "SHOW ME THE ROCK WHICH WAS PROBABLY MADE UNDER WATER."

- ⬭ *No response (If no response after probe, end the exercise.)*

B. Why did you choose the rock you chose?

_____

_____

_____

Probe 2: If respondent says, "Because it is sandstone," "because it is granite," or words to that effect ask, "WHY DID YOU CHOOSE SANDSTONE (GRANITE)?"

TABLE B-8. Differences Between Group and National Performance -- Rock-Type Activity, Part A

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,281	59.7	2,253	71.3	2,176	77.8
Region						
Southeast	566	-8.3	567	-7.6	564	-4.0
West	557	2.5	557	8.5	529	1.6
Central	579	3.5	561	1.3	540	3.3
Northeast	579	1.7	568	-2.9	543	-1.7
Sex						
Male	1,153	3.6	1,114	2.1	1,068	4.8
Female	1,128	-3.8	1,139	-2.1	1,108	-4.9
Color						
Black	403	-18.6	389	-20.1	375	-17.7
White	1,722	4.1	1,684	3.3	1,675	3.1
Parental education						
No high school	109	-8.1	197	-10.7	164	-16.9
Some high school	119	-4.3	216	-10.6	267	-2.9
Graduated high school	585	-1.7	771	-0.4	689	-1.3
Post high school	805	8.8	840	6.8	925	5.1
Size and type of community (STOC)						
Low metro	224	-14.5	224	-9.3	229	-10.7
Extreme rural	235	-3.6	228	-4.3	210	0.5
Small places	763	1.4	729	0.0	762	2.0
Medium city	332	-0.5	315	-0.9	306	-5.6
Main big city	251	-4.3	245	-0.3	188	0.4
Urban fringe	260	7.9	282	3.1	250	1.3
High metro	216	4.9	230	6.7	231	5.1

TABLE B-9. Differences Between Group and National Performance – Rock-Type Activity, Part B

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,281	7.0	2,253	15.9	2,176	25.2
Region						
Southeast	566	0.8	567	-4.5	564	-4.0
West	557	1.5	557	10.3	529	4.0
Central	579	-1.5	561	-1.4	540	0.2
Northeast	579	-0.4	568	-4.4	543	-0.4
Sex						
Male	1,153	1.4	1,114	1.7	1,068	6.0
Female	1,128	-1.5	1,139	-1.7	1,108	-6.1
Color						
Black	403	-5.4	389	-12.2	375	-16.0
White	1,722	1.3	1,684	2.3	1,675	3.1
Parental education						
No high school	109	-2.6	197	-5.7	164	-15.1
Some high school	119	0.4	216	-4.6	267	-7.3
Graduated high school	585	0.6	771	-2.5	689	-0.2
Post high school	805	0.9	840	6.0	925	5.0
Size and type of community (STOC)						
Low metro	224	-4.5	224	-7.4	229	-11.5
Extreme rural	235	-2.9	228	-2.6	210	-3.5
Small places	763	2.9	729	0.2	762	3.9
Medium city	332	3.3	315	2.1	306	5.8
Main big city	251	-1.6	245	-3.5	188	-11.1
Urban fringe	260	-2.1	282	4.6	250	-5.5
High metro	216	-2.9	230	1.2	231	6.5

PHOTOCELL-BOX ACTIVITY

Give box and flashlight to respondent.

A. Shine the flashlight into the box at the hole *(point to hole).* Observe what happens. Tell me what you OBSERVE when you shine the light into the box.

_____

_____

_____

Probe 1: If respondent gives explanation rather than an observation, ask, "CAN YOU ACTUALLY OBSERVE THAT? WHAT CAN YOU ACTUALLY OBSERVE?"

B. What do you think happens INSIDE the box when the light is shined into the box?

_____

_____

_____

C. What do you think is in the box? You may lift the box or examine it closely, but do not try to take it apart or look inside.

_____

_____

_____

If respondent attempts to take box apart or look inside, remind him not to do this

○ *Apparatus failed.*

TABLE B-10. Differences Between Group and National Performance – Photocell-Box Activity, Part A

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,234	89.9	2,210	92.6	2,176	92.1
Region						
Southeast	559	-3.3	556	-2.6	564	0.5
West	544	-0.5	549	-0.6	529	-0.3
Central	554	1.7	557	1.3	540	-0.6
Northeast	577	1.7	548	1.4	543	0.5
Sex						
Male	1,136	-1.4	1,093	-1.9	1,068	-0.1
Female	1,098	1.5	1,117	1.9	1,108	0.1
Color						
Black	398	2.1	386	-1.2	375	1.7
White	1,683	-0.4	1,645	0.4	1,675	-0.2
Parental education						
No high school	105	-5.3	195	-2.1	164	0.8
Some high school	115	-4.6	210	-0.8	267	0.6
Graduated high school	576	-1.0	753	-0.9	689	-0.8
Post high school	782	2.8	825	1.7	925	0.5
Size and type of community (STOC)						
Low metro	220	1.1	223	-2.9	229	-1.4
Extreme rural	231	-5.4	222	-3.8	210	1.9
Small places	742	-1.1	710	0.3	762	-0.3
Medium city	319	0.3	305	0.5	306	-0.3
Main big city	250	-0.4	243	2.7	188	1.2
Urban fringe	259	2.9	279	-0.6	250	-1.5
High metro	213	3.8	228	2.0	231	1.9

TABLE B-11. Differences Between Group and National Performance – Photocell-Box Activity, Part B

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,234	5.1	2,210	16.7	2,176	25.4
Region						
Southeast	559	0.6	556	-2.2	564	-9.1
West	544	-0.8	549	1.9	529	2.8
Central	554	1.4	557	0.1	540	4.1
Northeast	577	-1.4	548	0.0	543	0.6
Sex						
Male	1,136	2.2	1,093	7.4	1,068	14.0
Female	1,098	-2.4	1,117	-7.5	1,108	-14.2
Color						
Black	398	-3.8	386	-11.6	375	-16.9
White	1,683	1.1	1,645	2.4	1,675	3.6
Parental education						
No high school	105	3.5	195	-8.5	164	-15.7
Some high school	115	3.5	210	-6.2	267	-9.8
Graduated high school	576	0.3	753	-1.4	689	-0.2
Post high school	782	0.8	825	6.6	925	5.3
Size and type of community (STOC)						
Low metro	220	-3.4	223	-6.2	229	-8.9
Extreme rural	231	-0.0	222	-2.3	210	3.6
Small places	742	1.7	710	-0.8	762	0.6
Medium city	319	-0.8	305	4.2	306	0.1
Main big city	250	-2.9	243	-4.7	188	2.4
Urban fringe	259	-0.5	279	4.0	250	-0.2
High metro	213	2.0	228	2.2	231	0.5

TABLE B-12. Differences Between Group and National Performance – Photocell-Box Activity, Part C

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,234	44.2	2,210	55.6	2,176	62.2
Region						
Southeast	559	-1.5	556	3.7	564	-2.1
West	544	-1.4	549	0.0	529	0.1
Central	554	2.8	557	0.0	540	1.9
Northeast	577	-0.3	548	-3.4	543	-0.5
Sex						
Male	1,136	9.0	1,093	10.6	1,068	12.1
Female	1,098	-9.6	1,117	-10.8	1,108	-12.3
Color						
Black	398	-9.8	386	-0.7	375	-7.5
White	1,683	3.2	1,645	1.0	1,675	1.9
Parental education						
No high school	105	3.2	195	-3.4	164	-8.7
Some high school	115	-13.7	210	-2.0	267	-2.6
Graduated high school	576	3.6	753	0.6	689	-0.4
Post high school	782	1.9	825	2.1	925	3.3
Size and type of community (STOC)						
Low metro	220	-9.4	223	-0.1	229	-3.0
Extreme rural	231	-1.5	222	-9.4	210	3.4
Small places	742	3.1	710	3.5	762	0.4
Medium city	319	-0.6	305	2.7	306	3.2
Main big city	250	-5.6	243	-8.1	188	0.2
Urban fringe	259	2.6	279	-0.5	250	-3.9
High metro	213	2.5	228	4.3	231	-0.5

ROTATION-AND-REVOLUTION ACTIVITY

Do not administer without verifying your understanding of ROTATION and REVOLUTION.

Place three spheres on table or other flat surface, with the Earth directly in front of respondent, the Sun about 1 foot from the earth sphere on respondent's left and the moon sphere about 6 inches from the earth sphere on respondent's right.

This ball represents the Sun. *(Point to large sphere.)*

This ball represents the Earth. *(Point to medium-sized sphere.)*

The North and South Poles are marked N and S. *(Show respondent.)*

The Equator is here. *(Show respondent.)*

This ball represents the Moon. *(Point to the smallest sphere.)*

A. Use any balls you may need to show me what causes a day and a night. You may move the balls around while you work out your answer. Then tell me when you are ready to demonstrate what happens in a 24-hour period to make one day and one night.

Observe respondent carefully as he demonstrates. He should correctly rotate (spin) the Earth on its axis, one complete turn.

If this is done, regardless of the direction of rotation and all other movements of the spheres, the demonstration is correct.

○ *Correct demonstration: Earth rotates one full turn (Go to B)*

○ *Incorrect demonstration, describe:*

_____

_____

_____

○ *I don't know. (Go to C)*

○ *Did not attempt demonstration (Go to C)*

B. In which direction would the Earth be spinning?

- ⬭ *Eastward (counterclockwise); says or demonstrates*
- ⬭ *Westward (clockwise); says or demonstrates*
- ⬭ *Other, says or demonstrates, describe:*

_____

_____

_____

- ⬭ *I don't know.*
- ⬭ *No response*

C. Now, use any balls you may need to show me what causes a year. Once again you may move the balls around while you work out your answer. Then, tell me when you are ready to demonstrate what happens in a 365-day period to make a year.

Observe respondent CAREFULLY as he demonstrates. He should correctly revolve (move) the Earth around the Sun, once completely.

If this is done, regardless of the direction of revolution and all other movements of the spheres, the demonstration is correct.

- ⬭ *Correct demonstration: Earth revolves one full turn around Sun (Go to D)*
- ⬭ *Incorrect demonstration, describe:*

_____

_____

_____

- ⬭ *I don't know. (End the exercise)*
- ⬭ *Did not attempt demonstration (End the exercise)*

D. In which direction would the Earth be revolving around the Sun?

- ◯ *Counterclockwise; says or demonstrates*
- ◯ *Clockwise; says or demonstrates*
- ◯ *Other; says or demonstrates, describe:*

_____

_____

_____

- ◯ *I don't know.*
- ◯ *No response*
- ◯ *Apparatus failed.*

TABLE B-13. Differences Between Group and National Performance – Rotation-and-Revolution Activity, Part A

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,244	34.5	2,176	48.1	2,176	53.1
Region						
Southeast	557	0.5	543	-4.0	564	-5.7
West	570	-1.3	530	1.1	529	5.3
Central	567	1.0	557	4.3	540	-3.3
Northeast	550	-0.4	546	-2.5	543	3.5
Sex						
Male	1,128	4.6	1,065	5.5	1,068	7.5
Female	1,116	-4.7	1,111	-5.3	1,108	-7.6
Color						
Black	401	-13.8	372	-16.5	375	-14.9
White	1,684	3.1	1,646	3.2	1,675	2.2
Parental education						
No high school	120	-6.6	169	-21.7	164	-16.4
Some high school	122	-10.7	236	-14.4	267	-13.4
Graduated high school	596	-4.2	730	1.6	689	-2.3
Post high school	818	7.3	817	10.8	925	8.3
Size and type of community (STOC)						
Low metro	232	-12.6	218	-2.3	229	-6.0
Extreme rural	228	-7.5	212	-6.9	210	-1.3
Small places	734	1.6	728	-1.9	762	-1.7
Medium city	334	1.1	295	0.6	306	8.3
Main big city	236	0.1	233	-6.8	188	-7.3
Urban fringe	265	4.7	262	5.1	250	-0.7
High metro	215	3.0	228	11.6	231	6.3

TABLE B-14. Differences Between Group and National Performance – Rotation-and-Revolution Activity, Part C

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,246	33.1	2,191	51.7	2,176	59.9
Region						
Southeast	557	-5.4	551	-7.5	564	-9.9
West	569	2.2	537	1.2	529	0.9
Central	569	1.0	554	-0.5	540	1.5
Northeast	551	1.9	549	6.3	543	5.7
Sex						
Male	1,127	6.0	1,066	6.4	1,068	8.2
Female	1,119	-6.2	1,125	-6.2	1,108	-8.3
Color						
Black	400	-21.4	376	-28.4	375	-24.8
White	1,687	5.0	1,656	5.5	1,675	4.2
Parental education						
No high school	119	-8.9	168	-27.1	164	-20.1
Some high school	123	-13.2	236	-17.6	267	-17.3
Graduated high school	597	-3.5	740	0.7	689	-1.1
Post high school	821	11.6	822	13.8	925	9.5
Size and type of community (STOC)						
Low metro	231	-18.1	223	-14.6	229	-16.1
Extreme rural	228	-7.7	209	-3.7	210	0.3
Small places	737	2.8	735	0.9	762	0.5
Medium city	333	0.7	296	-0.3	306	3.9
Main big city	236	-6.6	235	-6.0	188	-12.9
Urban fringe	265	6.0	264	5.2	250	1.3
High metro	216	8.3	229	8.6	231	11.4

FAULTING-AND-FOLDING ACTIVITY

Geology is the science which studies the Earth, the rocks of which it is made up, and the changes which take place at and beneath the surface.

Take out 2 foam rubber blocks. Pick up one of the foam rubber blocks and TWIST it to show respondent that it is resilient and can be deformed without harm. Place foam blocks side by side, touching each other and lined up EVENLY, in front of respondent like this:

A. The foam sheets represent a layer of rock in the Earth's crust. Use one or both of the foam blocks to demonstrate faulting of the Earth's crust; that is, show me a fault.

- ⬭ *Correct demonstration*
- ⬭ *Incorrect demonstration*
- ⬭ *I don't know.*
- ⬭ *Did not attempt demonstration*

B. Use one or both of these foam blocks to demonstrate a fold in the Earth's crust.

- ⬭ *Correct demonstration*
- ⬭ *Incorrect demonstration*
- ⬭ *I don't know.*
- ⬭ *Did not attempt demonstration*
- ⬭ *Apparatus failed.*

TABLE B-15. Differences Between Group and National Performance – Faulting-and-Folding Activity, Part A

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,213	4.4	2,267	19.8	2,159	33.5
Region						
Southeast	565	-1.1	571	-3.7	549	-3.9
West	555	2.2	561	0.5	542	3.7
Central	546	-0.2	566	1.0	529	1.6
Northeast	547	-0.8	569	1.8	539	-2.2
Sex						
Male	1,074	1.7	1,105	5.7	1,041	8.3
Female	1,139	-1.6	1,162	-5.6	1,118	-7.9
Color						
Black	402	-2.4	399	-10.0	344	-14.1
White	1,638	0.6	1,689	2.6	1,692	2.5
Parental education						
No high school	113	-3.4	188	-12.1	165	-4.5
Some high school	116	3.1	233	-7.7	264	-11.3
Graduated high school	508	-1.1	762	-3.2	676	-0.0
Post high school	827	2.4	839	8.6	937	4.1
Size and type of community (STOC)						
Low metro	232	-2.7	214	-12.1	226	-6.6
Extreme rural	215	-1.9	224	-3.5	205	-3.5
Small places	718	-1.6	750	2.7	774	-0.2
Medium city	309	1.8	312	-1.2	301	0.9
Main big city	251	3.1	269	-2.6	189	-0.5
Urban fringe	255	0.6	272	2.3	252	-0.3
High metro	233	1.6	226	3.6	212	7.2

TABLE B-16. Differences Between Group and National Performance – Faulting-and-Folding Activity, Part B

	Age 9		Age 13		Age 17	
	N-Count	Percent	N-Count	Percent	N-Count	Percent
National	2,213	16.0	2,267	22.2	2,159	32.4
Region						
Southeast	565	-0.1	571	-5.4	549	-7.9
West	555	1.2	561	-0.5	542	6.7
Central	546	3.0	566	3.3	529	3.6
Northeast	547	-4.1	569	1.5	539	-4.2
Sex						
Male	1,074	0.8	1,105	4.7	1,041	8.4
Female	1,139	-0.8	1,162	-4.6	1,118	-8.0
Color						
Black	402	-9.4	399	-8.0	344	-10.0
White	1,638	1.9	1,689	1.9	1,692	1.6
Parental education						
No high school	113	-2.1	188	-3.8	165	-0.3
Some high school	116	2.0	233	-8.1	264	-7.5
Graduated high school	508	-0.9	762	-1.8	676	-4.1
Post high school	827	4.7	839	6.3	937	6.0
Size and type of community (STOC)						
Low metro	232	-9.7	214	-6.5	226	-6.7
Extreme rural	215	-4.9	224	-3.9	205	1.5
Small places	718	4.6	750	2.6	774	2.3
Medium city	309	2.2	312	1.7	301	0.8
Main big city	251	-0.7	269	-2.9	189	-0.1
Urban fringe	255	0.8	272	-1.9	252	-5.3
High metro	233	-4.2	226	3.2	212	2.5

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